DETECTION RANGE OF 500-KC./SEC. SFERICS

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ABSTRACT

An investigation of the effective maximum range of detection of 500-kc./sec. sferics was conducted by examining recorded sferics data from widely separated locations and also during times when a circular area surrounding the detector was devoid of both radar echoes and severe weather events. Sferics were recorded from all severe weather events identified by radar as well as all severe weather events listed in *Storm Data* within 200 mi. of the detector. As the range radius of the clear area was increased beyond 200 mi., the number of severe weather events which failed to give detectable sferics pulses increased rapidly.

1. INTRODUCTION

Omni-directional and directional measurements of electromagnetic radiation detectable at 500 kc./sec. have been related to towering cumulus and cumulonimbus cloud activity in prior studies [1, 2, 3, 4]. The ground-based detection equipment used for obtaining the data utilized in those studies consistently indicated zero sferics pulse background whenever available weather data contained no evidence of vertically developed cloud formations within a radius of 200 mi. The zero background characteristic is important in the utilization of monitor equipment at this frequency in an operational sense.

The limit of detectability of 500 kc./sec sferics is determined by the nature of the source of radiation, its height above ground, radio propagation conditions at 500 kc./sec., and the pulse threshold sensitivity of the detector. The tuned circuits of the sferics receivers used have a bandwidth of 15 kc./sec.; they are shock-excited by sferics impulses and produce damped sinusoid pulse responses. The minimum pulse detection threshold of the detector corresponds to a RF carrier field intensity of 400μv./m.

Weather radar and severe weather events (SWE) obtained from *Storm Data* [5] were used to show that during the 1962 National Severe Storms Project (NSSP) field operation no SWE occurred within 200 mi. of the sferics receiver without producing radiation detected at 500 kc./sec. [3]. In the present study,[1] SWE ranging out to 500 mi. are compared with sferics activity recordings in order to define the effective range of detectability. It has been pointed out [6] that SWE reported by *Storm Data* are not comprehensive enough for critical severe storm research purposes. Nevertheless, a proportionality between the *number* of SWE within a 200-mi. radius and the total *number* of 500-kc./sec. pulses per day exists in the 1962 data [3]. In a comparison between 1962 and 1963 NSSP sferics-SWE data [7], the total number of sferics pulses detected during a comparable 45-day period in each year was closely proportional to the total number of SWE reported in *Storm Data*.

This study uses WSR–57 radar PPI films, *Storm Data*, and recorded sferics measurements obtained in Oklahoma and Minnesota during 1962–63–64. In Minnesota, two monitor sites (Minneapolis and Hackensack) separated by 170 mi. were used to provide comparison of responses to activity located in their common detection area. The separation also permitted direct measurements of the maximum detection range limit in those instances during which the activity was located within range of one station but at a much greater distance from the other.

2. RADAR AND SFERICS

The method of analysis used throughout this study is based upon defining a circular area of range radius, R_c, which is completely devoid of either radar echoes or SWE or both. Further, it is required that echoes and SWE do exist at ranges just beyond the "clear" circle. The recorded data were examined to find as many different clear circle situations as possible to obtain a broad range sampling. This resulted in measurements distributed as shown at the bottom of table 1 under Summary of Sampling. At large ranges, the number of instances satisfying the definition of clear circles becomes small.

If, for any R_c defining the boundary of the clear area, sferics activity from any direction is present at the time, it is assumed that the source of sferics pulses lies in the activity beyond the clear circle.

The comparison of the radar at maximum sensitivity with sferics activity is shown in the distribution at the top of table 1. The radar films were those made by the U.S. Weather Bureau in their NSSP radar observational program for 1962–63 plus a limited sample from the NSSL data. The number of instances in which echoes beyond the clear circle failed to produce sferics activity was a small fraction of those with activity. The radar data are therefore typical of stormy situations producing sferics activity.

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TABLE 1.—*Summary of range dependent measurements of 500-kc./sec. sferics, radar echoes, and severe weather events*

R_c (range in statute miles)	Less than 25	25–49	50–74	75–99	100–149	150–199	200–249	250–299	300–500
WSR-57 RADAR ECHOES AND SFERICS									
Echoes with sferics	76	55	54	52	35	15	11	—	—
Echoes without sferics	2	3	1	1	3	3	3	—	—
SEVERE WEATHER EVENTS IDENTIFIED BY RADAR AND SFERICS									
Echoes with severe weather and with sferics	2	2	1	7	1	6	0	—	—
Echoes with severe weather but without sferics	0	0	0	0	0	0	0	—	—
SEVERE WEATHER EVENTS AND RADAR ECHOES AND SFERICS									
Both echoes and severe weather with sferics	25	13	18	16	5	3	2	—	—
Both echoes and severe weather without sferics	0	0	0	0	0	0	1	—	—
SEVERE WEATHER EVENTS AND SFERICS									
Severe weather events with sferics	9	6	21	27	63	55	8	0	0
Severe weather events without sferics	0	0	0	*0	0	0	10	12	65
SUMMARY OF SAMPLING									
Total number of radar echoes measured	78	58	55	53	38	18	14	—	—
Total number of severe weather events checked	9	6	21	27	63	55	82	109	205

—No data.
* *Storm Data* lists 2 SWE in this range category which cannot be verified by independent data. See text.

3. RADAR, SEVERE WEATHER EVENTS, AND SFERICS

Radar echoes with associated SWE occurring just beyond the clear circle comprise the next distribution in table 1, Severe Weather Events Identified by Radar and Sferics. The total sample in this category is small because of the restricted data selection imposed by requiring a clear circle surrounding the radar and sferics monitoring site for each range increment.

Sferics activity was present for every instance of SWE identified by radar out to the range limit of available radar data.

When both radar echoes and severe weather occurred just beyond the clear circle formed by R_c, the resulting distribution is shown in table 1, Severe Weather Events and Radar and Sferics. It is significant that in this distribution as well as the previous one, there are no instances of echoes and/or SWE occurring within 200 mi. which failed to have sferics activity.

In consideration of SWE independent of radar manifestations, the next distribution of table 1, Severe Weather Events and Sferics, shows that all SWE out to 200 mi. produced sferics. The number of SWE at each range shows an increasing trend with greater clear circle range radii because the increase in area is proportional to range. Beyond 200 mi., however, the number of SWE occurring when the sferics activity is zero begins to increase rapidly confirming the lack of detection at those ranges.

Within 200 mi. there were 181 SWE which occurred with sferics activity. None occurred without sferics activity; however, there were two SWE listed in *Storm Data* which have been classified as doubtful entries. They both occurred between 75 and 100 mi. from the monitor sites. In one instance of a reported hail storm there were no radar echoes within 200 mi. at the time. The other, a funnel cloud sighting, occurred within the common detection area of the two monitors, both of which indicated zero, and was 80 mi. from the nearest radar echo.

The distribution of kinds of SWE which occurred within 200 mi. is shown in figure 1. The composition of this sample, representing 31 percent of all SWE checked, is closely proportional to all of those which occurred between 200 to 500 mi. confirming the statistical representativeness of those SWE which did produce sferics within 200 mi.

The distributions in time of the radar measurements and SWE are shown in figure 2. Measurements of radio propagation at 500 kc./sec. indicate an average first hop-skip-distance[2] of 350 mi. for the sky wave energy reflected from the ionosphere at night [8]. If this relationship also holds true for the elevated sferics sources in and about thunderstorms, there would be little diurnal effect upon received signal strength at closer ranges. The lack of sferics activity from SWE occurring at ranges between 250 to 500 mi. (table 1) from measurements obtained at all hours of the day and night, is evidence of no diurnal variation in sferics pulse amplitudes.

4. CONCLUSIONS

In the preparation of data presented in this study, the investigation of periods of zero sferics activity was emphasized. The finding that all severe weather events and

[2] This is the distance from a ground-based transmitter to the first range at which the skywave exceeds the groundwave signal strength by 10 db.

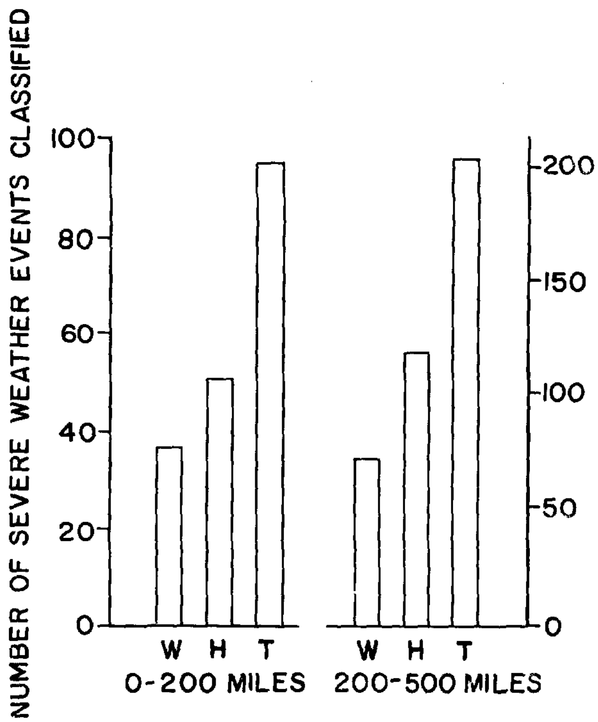

FIGURE 1.—Classification of severe weather events occurring within 500-kc./sec. sferics detection range in comparison with those occurring beyond range. T is tornado or funnel cloud, H is hailstorm, and W is windstorm. Sferics measuring locations: Shawnee and Arapaho, Okla. (May–June 1962); Norman, Okla. (May–June 1963–64); Minneapolis and Hackensack, Minn. (July–August 1963–64).

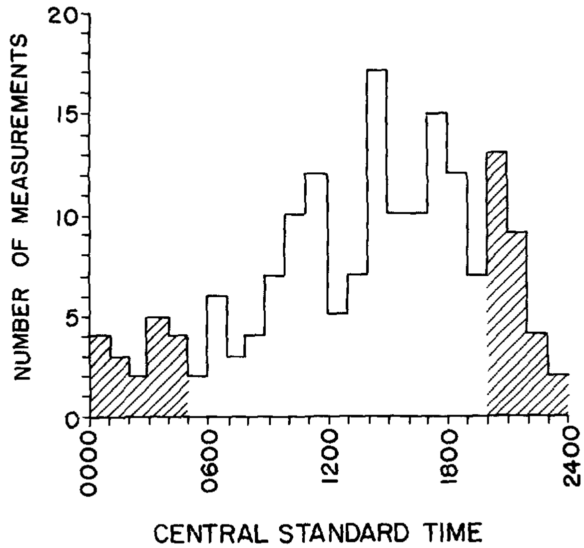

FIGURE 2.—Distribution in time of "clear" circle radar PPI measurements used with corresponding severe weather and sferics data. Average nighttime data are shown shaded. WSR-57 radar locations at Oklahoma City (May–June 1962) and Norman, Okla. (May–June 1963 and May 1964).

associated radar echoes occurring within 200 mi. produced 500-kc./sec. sferics, provides the significance to the results of the sferics zero background period examinations. The occurrence of SWE during zero background periods at ranges between 200 to 250 mi., indicates this is a transition zone from detection to non-detection which existed for every case of numerous SWE occurring beyond 250 mi. The maximum effective range of detection thus lies between 200 and 250 statute miles.

The distribution in range of SWE and sferics in table 1 includes only 26 of 180 SWE within 200 mi. examined in the 1962 analysis by Kohl and Miller [3]. Their findinsg, on the basis of available data, that 500-kc./sec. sferics were always produced during the occurrence of SWE has thus been extended by this study to cover three years and two locations with markedly different climatological conditions.

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